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Behavioral and sociodemographic correlates of sleep duration among children in Samoa

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ABSTRACT

Objectives: To describe sleep duration, adherence to sleep recommendations, and behavioral and sociodemographic correlates of sleep among Samoan children.
Methods: In a longitudinal cohort study of Samoan children aged 2-9 years (n = 481; 50% female), primary caregivers reported usual number of hours of nighttime sleep during 2015, 2017/2018, and 2019/2020 data collection waves. Associations between behavioral and sociodemographic characteristics and sleep duration were assessed using generalized linear and mixed effect regressions.
Results: Average reported hours of nighttime sleep for toddlers (age 2) was 9.7 ± 1.1 (SD); for preschoolers (age 3-5) 9.5 ± 1.0, and for school-age children (age 6-9) 9.4 ± 1.3, with 58% of children meeting sleep recommendations. Living in a lower income household was associated with 30 more minutes of sleep for toddlers (adjusted β:0.56 [95% CI: 0.03, 1.09]) and preschoolers (adjusted β:0.51 [95% CI: 0.17, 0.85]), while higher reported physical activity was associated with longer sleep for school-age children (adjusted β:0.49 [95% CI: 0.08, 0.91]). Preschoolers with a primary caregiver who did not complete high school had shorter sleep (β: − 0.80 [95% CI: − 1.12, − 0.48]). Among school-aged children, shorter sleep was associated with greater total carbohydrate intake (for every 100 g/day, β: − 0.01 [95% CI: − 0.02, 0.01]) and neotraditional dietary pattern adherence (β: − 0.27 [95% CI: − 0.53, − 0.01]).
Conclusions: Efforts should be made to encourage adequate sleep among Samoan children. Correlates of sleep were largely consistent with existing literature. Future research should examine additional culturally and contextually-specific risk factors for insufficient sleep in Samoa and consequences for child health.

Introduction

Sleep plays an important role in child health and development.[1] For example, insufficient sleep negatively impacts both energy intake and energy expenditure, and thus sleep duration is negatively associated with both childhood[2] and long-term obesity risk.[3] Sleep duration is also negatively associated with behavioral problems in children.[4] On the other hand, it is positively associated with cognitive performance, particularly executive functioning, and school

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performance, Sleep problems in childhood are further concerning because they are predictive of poor sleep outcomes in subsequent years,[5] and insufficient sleep in adulthood is associated with adverse health consequences including cardiovascular disease, type 2 diabetes, and mortality.[6]

The World Health Organization (WHO) recommends that toddlers (1-2 years) sleep between 11 and 14 hours per day and preschoolers (3-5 years) sleep between 10 and 13 hours per day.[7] These recommendations mirror United States National Sleep Foundation guidelines, which extend to school-aged children (6-13 years), recommending that they sleep between 9 and 11 hours per day.[8] Many children globally, especially younger children, do not meet age-based recommendations[9] and global secular trends toward decreased sleep duration have been observed.[10] The vast majority of the existing research on infant and childhood sleep duration, its correlates, and its association with obesity risk has, however, taken place in high income settings.[9,11]

Little is currently known about child sleep in Samoa, a low-middle income island nation with a uniquely high burden of obesity and related cardiometabolic disease. Among children taking part in the *Ola Tuputupua'e* ("Growing Up") study – a mixed longitudinal cohort study – in Samoa, we have previously reported an increase in prevalence of obesity from 16% among 2- to 4-year-olds to 25% among 3.8- to 6-year-olds.[12] Our prior work in Samoa has reported poor sleep health among adults (a high prevalence of excessive daytime sleepiness[13] and worrisome levels of sleep apnea)[14] but to date, no attempts have been made to explore sleep duration or its correlates among children. Culture, demographic characteristics, household architecture and environment, and family sleep hygiene practices likely all differ in low-middle income settings compared to high-income settings.[15-18] Because the current evidence on correlates of sleep duration has generally been generated in high-income settings, assessments in low-middle income settings are warranted. Additionally, Samoa has seen an increasing prevalence of obesity, rapid economic development, and ongoing nutritional transitions toward increased consumption of high fat, high sugar foods (that are not found in neotraditional diets) and increased sedentary activities.[19-22] These behavioral and sociodemographic factors have been previously shown to be associated with shorter sleep duration and poor sleep outcomes in other populations,[2] but have not yet been explored among children in this setting.

Here, we describe sleep duration among Samoan children and the proportion of children aged 2 to 9 years in Samoa who are meeting age-appropriate sleep recommendations. We also examine behavioral and sociodemographic factors associated with sleep duration and the association of sleep with childhood body mass index (BMI).

Participants and methods

Study design and data collection

This secondary analysis used three waves of data collected from the ongoing *Ola Tuputupua'e* ("Growing Up") cohort in Samoa. Data collection took place between 2015 and 2020. The overarching goal of this cohort study is to longitudinally explore child health and development to inform preventative noncommunicable disease interventions and policy in Samoa. As previously described,[23] in 2015, 319 mother/primary caregiver–child dyads were enrolled from 10 Samoan villages using convenience sampling. The sample was purposively selected to equally represent the three Samoan census regions on the main island of 'Upolu with the goal of examining variation in health by urbanization and exposure to nutrition transition. The Apia Urban Area has the greatest exposure to nutrition transition, the surrounding Northwest Upolu region becomes increasing rural with distance from the urban center and has variable exposure to nutrition transition, while the Rest of Upolu is rural and least exposed. Dyads were eligible to participate if both were Samoan based on report of four Samoan grandparents (an approach shown previously to result in a sample of homogenous genetic Samoan ancestry)[24] and children were 2-4 years old at enrollment in 2015 (wave one). In 2017-2018 (wave two), we followed up with children in the original cohort and recruited new participants who met the original eligibility criteria (at age 4-6 years) to expand the cohort to a total of 501 children across 11 villages in 'Upolu. In 2019-2020 (wave three), the retention rate was 87.8% with 440 dyads of children and their primary caregivers who completed follow-up assessments.

University Institutional Review Boards (IRB # 2000020519 and IAA #18-41 959) and the Health Research Committee of the Samoan Ministry of Health approved all study procedures. At each data collection wave, written informed consent was obtained from parents. Children under seven provided verbal assent and written assent was obtained from children at 7 years or older (as required by Yale).

Sample

For a complete case analysis, we included children at ages 2-9 years for whom hours of sleep was reported during at least one wave of data collection and no data was missing for any of the variables described below. A total of 481 children are represented in the final analytic sample, with sleep duration reported for n = 312 out of the 319 children initially enrolled in wave one. Most (81.9%) children had sleep duration data reported during more than one wave of data collection (n = 238 for two waves and n = 156 for three waves).

Sleep outcomes

The primary outcome of interest was sleep duration based on the response of primary caregivers to the question: "How many hours does your child usually sleep at night?". We also explored sleep categorically using the age-based sleep duration recommendations by the WHO[7] and US National Sleep Foundation.[8] Recognizing that our question asked about nighttime sleep, and the recommendations describe sleep in a 24-hour period (i.e., including naps), we did not explore correlates of adherence to sleep recommendations and limit our analyses to descriptions by age group. At age 2 years, toddlers were classified as meeting the recommendation if ≥11 hours of sleep were reported by primary caregivers. At age 3-5 years, preschoolers met the recommendation if ≥10 hours of sleep were reported. At age 6-9 years, school-age children met recommendations if ≥9 hours of sleep were reported.

Child and sociodemographic characteristics

Various characteristics were selected to describe the study population and were identified as potential correlates of sleep based on prior literature.[2] Child characteristics were reported by primary caregivers at each data collection wave. Caregivers reported their child's sex and birth date. Age was calculated in years by subtracting the maternal reported birth date from the date of assessment. We also asked caregivers whether their children were attending school at the time of assessment (yes or no).

For sociodemographic characteristics, the highest level of primary caregiver education attained at the time of assessment was assessed by the number of reported years of education and dichotomized based on whether or not the caregiver completed high school. In line with census categories,[25] primary caregivers reported total annual household income, which we dichotomized as ≤$10,000 vs. > $10,000 Western Samoan Tala (WST) based on response distribution. Primary caregivers also reported the number of consumer durables owned in the household using an 18-item household asset index. From this a score was calculated to estimate household socioeconomic resources; an approach previously used in Samoa.[26] Higher household asset scores indicate greater socioeconomic resources. Finally, the village of residence of each child was categorized into census regions; urban vs. rural residence was determined based on whether or not households were located in the Apia Urban Area or other census regions.

Weight status and related behavioral characteristics

Weight status and energy balance-related behaviors were also examined as potential correlates of sleep based on prior literature.[2] We used WHO child growth standards and references to construct a dichotomous indicator of overweight/obesity (i.e., children under 5 were classified as having overweight/obesity if they had a body mass index-for-age Z-score (BMIz > +2SD,[27] whereas a cutoff of 1 SD was used for children 5 and older)[28] using age, sex, and average measurements of duplicate weight (HD 351 Weight scale, Tanita Corporation of America, IL) and standing height (Stadiometer Pfister Imports, NY).

Related to energy intake, we assessed daily carbohydrate intake and adherence to a neotraditional dietary pattern – a generally healthier, more locally-derived diet, which included high intakes of fruits, vegetables, tomatoes, banana-based local dishes, and soups.[29] Child dietary intake was ascertained from food frequency questionnaire data with a 30-day reference period. The consumption frequency of food items was reported using seven categories ranging from “never/less than once per month” to “more than six times per day.” We calculated daily total energy and nutrient intakes by multiplying frequency of consumption by the nutrient content of a fixed, standard portion size. Then, estimated daily carbohydrate intake was adjusted for total energy intake using the residual method.[29] The neotraditional dietary pattern was identified using factor analysis with principal component method, as previously described.[29] Neotraditional dietary pattern factor scores were categorized into quartiles based on the factor score distribution at each data collection wave.

Related to energy expenditure, we calculated 15-point physical activity scores using the Netherlands physical activity questionnaire for children, which has been used in this age group in other settings and adapted for use in this setting.[30,31] Higher physical activity scores indicated maternal report of greater physical activity compared to other peers the same age and scores were categorized into tertiles based on score distribution. Given associations between physical activity, screen time, and sleep in young children, we also examined television time as a potential correlate.[32] We asked caregivers, “On average, how many hours per day does your child spend watching any type of television, including video movies?” to estimate the amount of daily television time.

Statistical analyses

Means and standard deviations were calculated for continuous demographic characteristics, while frequencies and proportions were calculated for categorical demographic characteristics for each wave of data collection (2015, 2017/2018, and 2019/2020). Likewise, means and standard deviations were calculated for sleep duration, while frequencies and proportions were calculated for meeting sleep recommendations for each age group toddlers (2 years), preschool-age (3-5 years), and school-age (6-9 years). We then assessed the bivariate cross-sectional associations between child characteristics, behavioral, and sociodemographic factors, and sleep duration for the different age groups (toddlers, preschoolers, and school-age children) using a series of linear regressions. Multivariable regression models, stratified by age group and based on a priori hypotheses, were then constructed to assess associations between child characteristics (model 1), sociodemographic characteristics (model 2), and zBMI, diet-, and activity-related factors (model 3) with sleep duration across the waves. Mixed effects models were used to account for the fact that data was repeated within participants and allow for both time varying and time-invariant factors. Analyses were performed using StataSE (*Stata: Software for Statistics and Data Science*, 2020), with alpha-level set at 0.05.

Results

Sample characteristics

The sample included children ranging in age from 2-5 years in 2015, 3-7 years in 2017/2018, and 6-9 years in 2019/2020. Half of the children (50%) were female, with most children from families that had an annual household income less than 10,000 WST (57%-81% across the waves of data collection). Per the study design, region of residence was evenly distributed in the sample. These and other

Table 1
Sample characteristics

	2015 (n=289)	2017/2018 (n=354)	2019/2020 (n=369)
Child characteristics			
Sex			
Male	147 (51)	173 (49)	177 (48)
Female	142 (49)	181 (51)	192 (52)
Age (y)[a]	3.39 (0.92)	5.34 (0.92)	8.04 (0.92)
Attends school	49 (17)	257 (73)	361 (98)
Overweight/obesity[b]	49 (17)	82 (23)	137 (37)
Diet behaviors			
Neotraditional dietary pattern[c]			
Quartile 1 (Lowest adherence)	70 (24)	88 (25)	–
Quartile 2	74 (26)	92 (26)	–
Quartile 3	73 (25)	93 (26)	–
Quartile 4 (Highest adherence)	72 (25)	81 (23)	–
Carbohydrate intake (mean 100 g per day)[c]	3.50 (0.41)	5.25 (0.53)	2.18 (0.24)
Physical activity tertile[d]			
Low (0-12)	115 (40)	207 (59)	238 (65)
Medium (13-14)	65 (22)	128 (36)	88 (24)
High (15)	109 (38)	19 (5)	43 (12)
Television time (mean hours per day)	1.12 (0.78)	1.40 (1.47)	1.77 (1.37)
Sociodemographic characteristics			
Primary caregiver education (< high school completed)[e]	113 (39)	26 (7)	70 (19)
Total household annual income (< $10,000 WST)[f]	227 (79)	288 (81)	212 (57)
Household asset score[a,g]	5.65 (3.70)	5.74 (4.18)	4.53 (3.67)
Census region (Urbanicity)			
Apia urban area (urban)	91 (31)	111 (31)	122 (33)
Northwest Upolu (peri-urban)	99 (34)	128 (36)	134 (36)
Rest of Upolu (rural)	99 (34)	115 (32)	113 (31)

Abbreviation: WST, Western Samoan Tala.
[a] Mean (SD) presented, as opposed to n (%).
[b] Defined as zBMI > +2 SD for under 5 and > +1 SD for 5 years and older using WHO child standards and references.
[c] Adjusted for total energy intake. Since a neotraditional dietary pattern was not identified in 2019/2020, this variable was not available to be included for the analyses.
[d] Based on the score distribution of Netherlands Physical Activity Questionnaire.
[e] At the time of the initial recruitment in either 2015 or 2017/2018, mothers were enrolled in the study and in 2019/2020, either mothers or the primary caregiver of the child participated.
[f] Dichotomized based on the category of total annual income for the household.
[g] Based on the sum of 18 consumer durable assets that were owned in the household such as a television or refrigerator.

Table 2
Sleep characteristics

	2015 (n = 289)	2017/2018 (n = 354)	2019/2020 (n = 369)	p-value
Daily sleep duration (hours/night)[a]				
All children	9.49 (1.05)	9.81 (1.49)	9.33 (1.14)	.009
By age group				
Toddlers (2 y)	9.48 (1.08)	–	–	–
Preschool-age (3-5 y)	9.50 (1.03)	9.83 (1.47)	–	.012
School-age (6-9 y)	–	9.76 (1.57)	9.33 (1.14)	.001
Met National Sleep Foundation recommendation[b]				
All children	83 (29)	218 (62)	288 (78)	< .001
By age group				
Toddlers (≥11 h)	16 (14)	–	–	–
Preschool-age (≥10 h)	67 (39)	144 (56)	–	< .001
School-age (≥9 h)	–	74 (75)	288 (78)	.400

p-value is for time trend using a longitudinal model.
[a] Mean (SD) presented.
[b] n (%) presented.

sociodemographic and behavioral characteristics for the sample for each wave of data collection are presented in Table 1.

Child sleep

Table 2 summarizes the sleep characteristics of the sample. Average nighttime sleep duration for toddlers (2 years) was 9.7 (Standard Deviation [SD] = 1.1) hours per day, with toddlers meeting their sleep recommendation (of ≥11 hours) 14% of the time. Average sleep duration for preschool-age children (3-5 years) was 9.5 (SD = 1.0) hours per day, with preschool-age children meeting their sleep recommendation (of ≥10 hours) 49% of the time. Finally, average sleep duration for school-age children (6-9 years) was 9.4 (SD = 1.3) hours per day, with school-age children meeting their sleep recommendation (of ≥9 hours) 77% of the time. Across the whole sample, children met their age-specific sleep recommendation 58% of the time.

Bivariate associations with sleep duration by age group

Table 3 shows bivariate associations between child characteristics, behavioral and sociodemographic factors for the different age groups. For toddlers, annual household income < $10,000 WST (β = 0.66, 95% CI [0.19, 1.14]), urbanicity (β = 0.25, 95% CI [0.01, 0.49]), and BMI z-score (β = 0.22, 95% CI [0.00, 0.45]) were associated longer nighttime sleep duration. For preschool-age children, annual household income < $10,000 WST (β = 0.47, 95% CI [0.17, 0.77]) and physical activity tertile (β = 0.16, 95% CI [0.00, 0.32]) were associated with longer sleep duration, while having a mother that had not completed high school (β = − 0.55, 95% CI [− 0.85, − 0.25]) was associated with shorter sleep duration. Finally, for school-age children, school attendance (β = 1.04, 95% CI [0.26, 1.82]) was associated with longer sleep duration, while having a mother that had not completed high school (β = − 0.34, 95% CI [− 0.65, − 0.03]), neotraditional dietary pattern quartile (β = − 0.49, 95% CI [− 0.75, − 0.23]), and television time (β = − 0.10, 95% CI [− 0.18, − 0.02]) were associated with shorter sleep duration.

Multivariable associations with sleep duration by age group

Table 4 displays the results of the multivariable adjusted associations between child characteristics, sociodemographic factors, zBMI, and diet- and activity-related behaviors, across waves. For toddlers, annual household income < $10,000 WST (β = 0.87, 95% CI [0.37, 1.37]), caregiver education < high school completed (β = − 0.50, 95% CI [− 0.90, − 0.11]), and urbanicity (β = 0.30, 95% CI [0.07, 0.53]) were associated with sleep duration in model 2, while annual household income < $10,000 WST (β = 0.56, 95% CI [0.03, 1.09]), urbanicity (β = 0.30, 95% CI [0.08, 0.51]), and physical activity tertile (β = − 0.26, 95% CI [− 0.46, − 0.05]) were associated with sleep duration in model 3.

For preschool-age children, annual household income < $10,000 WST (β = 0.46, 95% CI [0.14, − 0.78]) and caregiver education < high school completed (β = − 0.72, 95% CI [− 1.03, − 0.41]) were associated with sleep duration in model 2, while annual household income < $10,000 WST (β = 0.51, 95% CI [0.17, 0.85]), asset score

Table 3
Bivariate cross-sectional associations of sociodemographic characteristics, zBMI, and diet- and activity-related factors with sleep duration (hours/night) for toddlers, preschoolers, and school-age children

		Toddlers (n = 116)	Preschool-age (n = 428)	School-age (n = 468)
Covariates	Female sex	0.04 [− 0.36, 0.43]	− 0.14 [− 0.39, 0.11]	0.07 [− 0.16, 0.30]
	Attends school	0.09 [− 0.74, 0.93]	0.00 [− 0.25, 0.25]	**1.04 [0.26, 1.82]**
Sociodemographic characteristics	Total household annual income (< $10,000 WST)	**0.66 [0.19, 1.14]**	**0.47 [0.17, 0.77]**	− 0.02 [− 0.26, 0.21]
	Asset score	− 0.02 [− 0.08, 0.03]	− 0.03 [− 0.06, 0.00]	0.01 [− 0.02, 0.04]
	Caregiver education (< high school completed)	− 0.29 [− 0.69, 0.12]	**−0.55 [−0.85, − 0.25]**	**−0.34 [−0.65, − 0.03]**
	Urbanicity	**0.25 [0.01, 0.49]**	− 0.05 [− 0.21, 0.10]	− 0.14 [− 0.28, 0.01]
zBMI, diet-, and activity-related factors	BMI z-score	**0.22 [0.00, 0.45]**	0.02 [− 0.11, 0.15]	0.00 [− 0.09, 0.09]
	Carbohydrate intake (for every 100 g/day)[a]	− 0.13 [− 0.58, 0.31]	− 0.08 [− 0.20, 0.05]	0.08 [− 0.01, 0.17]
	Neotraditional dietary pattern quartile	0.12 [− 0.05, 0.29]	− 0.06 [− 0.18, 0.05]	**−0.49 [−0.75, − 0.23]**
	Physical activity tertile	− 0.08 [− 0.31, 0.15]	0.16 [0.00, 0.32]	− 0.10 [− 0.26, 0.06]
	Television time (mean hours per day)	0.08 [− 0.18, 0.35]	0.00 [− 0.09, 0.10]	**−0.10 [−0.18, − 0.02]**

Abbreviation: WST, Western Samoan Tala.
[a] Adjusted for total energy intake; β [95% CI] presented for sleep duration; referent group for sex is male, income is $10,000 WST or higher, and primary caregiver education is completed high school; bold values indicate 95% CI does not include the null value of 0.

Table 4
Multivariable adjusted associations of sociodemographic characteristics, zBMI, and diet- and activity-related factors with sleep duration (hours/day)

Age group	Sleep duration (hours/day)		Model 1	Model 2	Model 3
Toddlers (n = 116)	Child characteristics	Female sex	0.03 [− 0.36, 0.42]	− 0.10 [− 0.46, 0.27]	− 0.12 [− 0.46, 0.21]
		Attends school	0.09 [− 0.73, 0.91]	0.09 [− 0.67, 0.85]	− 0.02 [− 0.71, 0.67]
	Sociodemographic characteristics	Total household annual income (< $10,000 WST)		**0.87 [0.37, 1.37]**	**0.56 [0.03, 1.09]**
		Asset score		− 0.01 [− 0.06, 0.04]	− 0.02 [− 0.07, 0.04]
		Caregiver education (< high school completed)		**−0.50 [−0.90, − 0.11]**	− 0.33 [− 0.72, 0.07]
		Urbanicity		**0.30 [0.07, 0.53]**	**0.30 [0.08, 0.51]**
	zBMI, diet-, and activity-related factors	BMI z-score			**0.20 [0.00, 0.40]**
		Carbohydrate intake (mean 100 g per day)[a]			0.00 [− 0.01, 0.00]
		Neotraditional dietary pattern quartile			0.07 [− 0.12, 0.26]
		Physical activity tertile			**−0.26 [−0.46, − 0.05]**
		Television time (mean hours per day)			0.07 [− 0.16, 0.29]
Preschool-age (n = 428)	Child characteristics	Female sex	− 0.14 [− 0.39, 0.11]	− 0.16 [− 0.40, 0.08]	− 0.13 [− 0.37, 0.11]
		Attends school	0.01 [− 0.24, 0.26]	− 0.10 [− 0.34, 0.15]	− 0.01 [− 0.26, 0.25]
	Sociodemographic characteristics	Total household annual income (< $10,000 WST)		**0.46 [0.14, 0.78]**	**0.51 [0.17, 0.85]**
		Asset score		− 0.02 [− 0.06, 0.01]	**−0.04 [−0.08, − 0.01]**
		Caregiver education (< high school completed)		**−0.72 [−1.03, − 0.41]**	**−0.80 [−1.12, − 0.48]**
		Urbanicity		− 0.05 [− 0.20, 0.10]	− 0.02 [− 0.17, 0.14]
	zBMI, diet-, and activity-related factors	BMI z-score			0.04 [− 0.09, 0.17]
		Carbohydrate intake (mean 100 g per day)[a]			**0.00 [0.00, 0.00]**
		Neotraditional dietary pattern quartile			− 0.10 [− 0.22, 0.02]
		Physical activity tertile			0.13 [− 0.04, 0.30]
		Television time (mean hours per day)			0.07 [− 0.02, 0.17]
School-age (n = 468)	Child characteristics	Female sex	0.06 [− 0.17, 0.28]	0.08 [− 0.15, 0.30]	− 0.01 [− 0.53, 0.52]
		Attends school	**1.03 [0.25, 1.81]**	**0.92 [0.13, 1.70]**	− 0.22 [− 2.15, 1.70]
	Sociodemographic characteristics	Total household annual income (< $10,000 WST)		0.06 [− 0.19, 0.31]	0.15 [− 0.69, 0.99]
		Asset score		0.01 [− 0.02, 0.05]	0.02 [− 0.05, 0.09]
		Caregiver education (< high school completed)		**−0.38 [−0.69, − 0.07]**	− 0.22 [− 1.40, 0.07]
		Urbanicity		**−0.17 [−0.31, − 0.02]**	− 0.01 [− 0.36, 0.34]
	zBMI, diet-, and activity-related factors	BMI z-score			0.20 [− 0.02, 0.41]
		Carbohydrate intake (mean 100 g per day)[a]			**−0.01 [−0.02, − 0.01]**
		Neotraditional dietary pattern quartile			**−0.27 [−0.53, − 0.01]**
		Physical activity tertile			**0.49 [0.08, 0.91]**
		Television time (mean hours per day)			− 0.02 [− 0.20, 0.17]

Abbreviation: WST, Western Samoan Tala.
β [95% CI]; model 1 adjusts for sex, age, and school attendance; model 2 additionally adjusts for sociodemographic characteristics, and model 3 additionally adjusts for zBMI, diet- and physical activity-related factors; referent group for sex is male, income is $10,000 WST or higher, and primary caregiver education is completed high school.
[a] Adjusted for total energy intake; bold values indicate 95% CI does not include the null value of 0.

(β = − 0.04, 95% CI [− 0.08, − 0.01]), and caregiver education < high school completed (β = − 0.80, 95% CI [− 1.12, − 0.48]) were associated with sleep duration in model 3.

For school-aged children, caregiver education < high school completed and urbanicity were also associated with sleep duration (in model 2, β = − 0.38, 95% CI [− 0.69, − 0.07] and β = − 0.17, 95% CI [− 0.31, − 0.02], respectively). However, none of these variables were associated with sleep duration in model 3, which further adjusted for zBMI, diet- and activity-related factors; instead, in this model, carbohydrate intake (mean 100 g per day) (β = − 0.01, 95% CI [− 0.02, − 0.01]), neotraditional dietary pattern quartile (β = − 0.27, 95% CI [− 0.53, − 0.01]), and physical activity tertile (β = 0.49, 95% CI [0.08, 0.91]) were associated with sleep duration.

Discussion

Samoan children, on average, had shorter sleep durations than recommended. However, some caution is required in interpreting the findings on adherence to sleep recommendations, particularly among the youngest age group for whom daytime naps were likely common and not accounted for in our data, Several of the associated characteristics were similar to the United States and other high-income countries, but some unique associations were also found. Thus, this study contributes to critically needed literature on sleep health in low- and middle-income country settings.

While global secular trends of shorter sleep durations have been reported,[10] the prevalence of insufficient sleep (i.e., not meeting the age-appropriate sleep recommendation) appears to be considerably higher in Samoa compared to high-income countries,[25-29] this is especially true among younger children and needs to be further explored in future studies. Even though our measure of sleep duration did not include naps - and younger children often meet their sleep needs with a combination of daytime and nighttime sleep[9,33] - the proportion of toddlers meeting sleep guidelines (14%) was markedly lower than has been reported in other settings.[34-38] For example, across studies conducted in the United States, Canada, Italy, Finland, and Australia, 67%-82% of toddlers met sleep guidelines.[34-39] Notably, average toddler sleep duration in our sample was lower than mean nocturnal sleep reported in some prior studies,[40] but similar to others,[39] thus cultural differences (e.g., regarding sleep parenting) may impact sleep among Samoan toddlers. While sleep parenting practices have yet to be assessed in this setting, a study examining cross-cultural differences in toddler sleep found that parents in predominantly Asian countries imposed later bedtimes and their children were more likely to room-share leading to shorter sleep compared to children in predominantly White countries.[9] Another study, a systematic review on cross-cultural comparative studies of sleep in children found that factors associated with sleep vary across countries underscoring the importance of setting-specific investigations.[17] Thus, further studies of sleep among Samoan children, especially toddlers, with more nuanced measures, including both daytime and nighttime sleep, are needed.

Across the whole sample, average nighttime sleep duration (9.5 hours) was similar to that reported in recent cross-cultural studies,[4,9] as well as in the Children's Healthy Living (CHL) Program – a study across five US-affiliated Pacific jurisdictions. Between 2012 and 2015, parents and caregivers reported nighttime sleep duration among children aged 2-8 years with sleep ranging from 9.2 hours in Guam to 10.2 hours in American Samoa (the average was 9.6 hours).[41] Sleep duration was somewhat longer than that reported in a study of Pacific children living in New Zealand (9.1 hours).[42] This is likely because the New Zealand sample consisted of slightly older children (i.e., 4-12 years as opposed to 2-9 years in our sample) and used actigraphy instead of parental report (which more likely reflects time in bed, rather than sleep time).

Considering the importance of sleep for health and development in childhood, understanding factors associated with sleep duration is important for identifying at-risk individuals and targeting intervention efforts. The majority of the associations we observed between sociodemographic characteristics and child sleep duration were consistent with prior literature.[43-45] However, in our sample, annual household income and primary caregiver education were associated with child sleep duration in opposite directions; lower education was associated with less sleep, whereas lower income was associated with more sleep. In contrast, a systematic review by Zhang et al examining correlates of sleep duration in early childhood, which consisted of 116 studies, found that children from low-income households were at increased risk for short sleep duration.[45] However, the authors noted that most studies were conducted in high- or middle-income countries and drew attention to the need for studies examining correlates of sleep in lower-income countries. In low- and middle-income countries such as Samoa, there may be many other correlates of sleep duration that have not been considered in the existing literature. For example, sleep may impacted by long travel times to school that result in earlier wake times, differing access to after-school or evening activities or expectations for homework, shared sleep environments with children not always consistently sleeping in the same room or bed, working hours of caregivers (based on activities related to subsistence farming, public/private sector employment, and/or informal employment for community/family obligations), shared responsibilities in the village that impact daily routines, lack of street lighting/electricity, or temperature-related reasons to complete activities in the early morning hours. Further studies are needed to examine such factors and how they might explain our finding that living in a higher-income household was associated with less sleep among this sample of Samoan children.

In the context of high levels of childhood obesity, which are known to be associated with child dietary intake in this setting,[29,46] we found that child sleep duration was negatively associated with diet-related behaviors, including carbohydrate intake among school-age children, consistent with prior studies.[47,48] Additionally, we found a negative association between sleep duration and neotraditional dietary pattern score among school-age children. A neotraditional diet, as opposed to a modern diet, is one that consists of few processed foods and is typically carbohydrate-rich given the inclusion of local starchy root crops and banana-based dishes. Neotraditional dietary pattern adherence was highest among low-income families, likely explaining this finding. With lower income households engaged in subsistence farming,[49] children often have access to local foods, are more likely to follow a neotraditional dietary pattern.[29]

While we did not find cross-sectional associations between sleep duration and BMI z-score in this sample, insufficient sleep has been shown to alter appetite hormones and increase hunger and cravings, particularly for high carbohydrate, energy-dense, and processed foods,[50,51] which may eventually lead to weight gain and contribute to obesity risk (highlighting a need for longitudinal studies). Insufficient sleep may also increase obesity risk via energy expenditure,[52] as insufficient sleep may lead to decreased activity. Indeed, in this study sleep and physical activity were positively associated among pre-school age children, which replicates an earlier study of 3-8 year olds from this cohort.[53] We also noted an negative association between sleep and television time among school-aged children, which is consistent with existing literature,[45] including the findings of the Pacific-based CHL program.[41] As interventions are considered to extend sleep duration, these age/stage-specific risk factors should be taken into account.

To our knowledge, this is the first study to examine sleep duration and its correlates in Samoan children and to attempt to quantify the prevalence of insufficient sleep. The findings add to a very limited literature on sleep health among children living in low-and middle-income countries, with a sample that includes children across three developmental age groups (i.e., toddlers, preschoolers, and school-age children), and explanatory variables at multiple levels (i.e., individual, primary caregiver, and household). However, the study is not without limitations. First, we were limited to the data available across the three data collection waves in the *Ola Tuputupua'e* cohort study. With no available data on napping behaviors, our estimates of the proportion of children (particularly in the toddler age group) meeting sleep recommendations (which are framed across 24 hours, without differentiating between nighttime and daytime sleep) should be interpreted with caution. This study also used a primary caregiver reported measure of child sleep duration. Objective measures, including those collected using actigraphy, would yield more accurate estimates of sleep duration. However, prior research suggests that parents tend to overestimate their children's sleep,[54] thus the prevalence of children not meeting their age-based sleep recommendation may be even higher than reported. It should also be noted that parent reported child sleep has been shown to be highly correlated with objectively measured sleep, so while parent reported sleep measures may lead to imprecise point estimates, they are useful for examining relative differences and significant correlates of sleep.[55] As we note above, there may be a number of cultural and contextual factors that influence child sleep in Samoa that were not captured by our questionnaires (which were developed using a primarily Westernized lens and informed by existing literature). More work, including qualitative work, may be needed to identify other important correlates of sleep in this setting. Future work should also consider health outcomes associated with short sleep, both using a longitudinal approach, and considering other metabolic risk factors beyond BMI. Although the generalizability of the presented findings may also be limited due the convenience sampling of the *Ola Tuputupua'e* cohort,[22] the work is still an important step toward improving sleep health for Samoans. Specifically, our findings suggest several modifiable behavioral factors that may be targeted in interventions to positively impact sleep among children in Samoa.

Author contributions

CCC and NLH lead the *Ola Tuputupua'e* project with support from CSU, TN, MSR, and RLD. TvA conceptualized the study with CCC and NLH. CCC cleaned the longitudinal data, completed dietary pattern analyses with DQ, and TvA analyzed the data with statistical support from SD. TvA, CCC, and NLH drafted the manuscript, and revised it with DQ, RLD, SD, and TN. All authors read and approved the final manuscript.

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Declaration of conflicts of interest

The authors have no conflict of interest to report.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2024.10.009.

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